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United States
Department of
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Forest Service

**Equipment
Development
Center**

Missoula, Mont.

Review of the AGLINE Code Compatibility with FSCBG Code Requirements

May 1984
3400—Forest Pest Management
8434 2802

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Review of the AGLINE Code Compatibility with FSCBG Code Requirements

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Prepared for
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Purchase Order No. 43-0343-2-1312
(Work under this purchase order was completed in March 1983)

A report on Technological Improvements Project 8E62P46, Rotary vs. Fixed-wing Spray Aircraft, funded by Forest Pest Management Staff, State and Private Forestry

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This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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TABLE OF CONTENTS

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FOREWORD

This report is published as a part of a USDA Forest Service program to improve the aerial application of pesticides, specifically by using pesticides and delivery systems tailored to the forest environment. The program is conducted jointly by the Equipment Development Center, Missoula, Mont., and Forest Pest Management Staff, Washington Office at Davis, Calif., under the sponsorship of State and Private Forestry.

Details of the aerial application improvement program are explained in two Forest Service reports, A Problem Analysis: Forest and Range Aerial Pesticide Application Technology (Equipment Development Center Rpt. 7934 2804, July 1979, Missoula, Mont.) and Recommended Development Plan for An Aerial Spray Planning and Analysis System (Forest Pest Management Rpt. FPM 82-2, February 1982, Davis, Calif.).

When planning an aerial spray operation it is necessary to predict the dispersion of the droplets comprising the spray. Because of the great range of droplet sizes the accurate prediction of the dispersion requires the use of two methods of prediction. The prediction of the dispersion of the smaller size droplets is accomplished by using a diffusion model. Such a model assumes the droplets are diffused throughout the air much like smoke or steam in the atmosphere. The spread of larger droplets is accounted for by using a trajectory type model that takes into account the aerodynamic, aircraft, and gravitational forces acting on the droplets.

Because of evaporation the overall size of the droplets decreases as the droplets fall. Thus, a complete description of the dispersion of a spray would require a particle trajectory model to describe the early time history of the dispersion and a diffusion model to describe the later time history when the droplets are very small.

The procedure for using such models would then be:

a. Use the trajectory model to predict the early time history of the droplets; and

b. Use the results of the trajectory model as input to the diffusion model, which would then enable the prediction of the later time history and the deposition pattern.

Computer programs based on the models have been developed. The diffusion model requires as input a specific mathematical representation of the distribution of the droplets. Because the trajectory model code does not directly provide for this specific representation, another code, called the AGLINE code, has been developed to transform the output from the trajectory code into the desired form. The accuracy of the transformation is measured by a figure of merit, FOM, which specifies how closely the output of the trajectory code is the required mathematical representation.

When the results of the particle trajectory code are such that the FOM has achieved a specified numerical value, the output from the AGLINE code is suitable for use as input to the diffusion model.

This report discusses the compatibility and/or suitability of various values of the FOM in providing satisfactory input to the diffusion model. The report also presents an overview of each model and the role each model plays in the dispersion process.

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

The U. S. Forest Service (USFS) has supported the development of the FSCBG aircraft spray model (Dumbauld, et al., 1980) and uses the model for predicting aircraft spray dispersion above canopies, the penetration of spray drops into and through canopies, and ground-level deposition of drops beneath canopies. The FSCBG model is also used to predict spray drift downwind from spray application areas. The FSCBG model contains an elementary aircraft wake effects model to account for the depression and other features of the spray cloud caused by vortices produced by the spray aircraft. Continuum Dynamics, Inc. has recently developed the AGDISP code (Teske, 1982a) under contract to NASA for computing the motion of agricultural materials released from aircraft, predicting the mean position of the material in time and space, and the position variance about the mean as a result of turbulent motions due to wake vortices and atmospheric turbulence. Under an agreement between the USFS Equipment Development Center and NASA Langley Research Center, Continuum Dynamics has also developed the AGLINE code (Teske, 1982b). The AGLINE code intepprets the results of the AGDISP code and generates information for use in developing initial inputs to the FSCBG model. The purpose of the AGLINE code is to improve the treatment of aircraft wake effects contained in the FSCBG model.

1.2 STUDY OBJECTIVE

The major objective of the work defined under Purchase Order No. 43-0343-2-1312 is to review the AGLINE code output for compatibility with the FSCBG computer model input requirements and for applications to USFS spray programs.

1.3 CONTENTS OF THE REPORT

Section 2 contains summary descriptions of the AGDISP, AGLINE and FSCBG codes and describes a spray scenario developed for examining the compatibility of the AGLINE code output with the FSCBG input requirements. The results of calculations for the spray scenario made using the AGDISP/AGLINE codes and the FSCBG code are described in Section 3. The conclusions of the study and recommendations for future work are given in Section 4.

SECTION 2

SUMMARY DESCRIPTION OF THE AGDISP, AGLINE AND FSCBG CODES AND THE SPRAY SCENARIO

2.1 THE AGDISP AND AGLINE CODES

Both the AGDISP and AGLINE computer codes have been recently developed by Continuum Dynamics Inc. under Contract No. NAS1-16031. While user's manuals for the codes are available (Teske, 1982a, 1982b), a mathematical description of the algorithms used by the codes is not yet available. According to the Teske (1982a), a Lagrangian approach is used to describe the motion of discrete drops (or particles) released from spray booms mounted along the trailing edge of the wing of an aircraft in level flight. The drops are assumed spherical in shape. The AGDISP code predicts the particle motions in the aircraft wake field under the assumption that the motion is influenced by aerodynamic drag, forces depending on the consequences of evaporation and by gravity. The aircraft vortex flow field solution can be obtained for fixed-wing fully rolled up tip vortices, fixed-wing Betz roll up, propeller slipstream effects and a helicopter flow field model. The trajectory of drops released along the wing at up to 60 locations is output as a function of time until either the maximum simulation time is reached, all drops evaporate or all deposit on the surface. Provision is made to plot the drop trajectories on Tektronix 40XX terminals using CDC plotting commands. The program is highly user interactive.

The AGLINE code (Teske, 1982b) uses results generated by the AGDISP code to generate an equivalent Gaussian distribution of drops for use in describing the initial distribution of the spray cloud for the FSCBG model. The code reads the plot field generated by the AGDISP code and computes a Gaussian distribution fitted to the drop positions in space at selected times after the drops were released. The AGLINE code outputs the mean position of the equivalent Gaussian distribution, the standard deviation of the distribution and a "figure of merit". When the Gaussian distribution exactly fits the drop distribution, the figure of merit (FOM) is unity. When there is no correlation between the drop positions and a Gaussian

distribution, the FOM is 0. The user must finally judge the compatibility of the Gaussian fit with the drop spatial distribution. The code can also be used to plot isopleths of the AGDISP calculated drop distribution overlayed with isopleths based on the fitted Gaussian distribution for user selected times to assist in judging the compatibility of the distributions. The inputs to the AGDISP and AGLINE codes selected for use in the calculations for the spray scenarios are described in Section 3. It should be mentioned that it was necessary for us to modify the AGDISP and AGLINE codes for batch processing on a UNIVAC 1100/60 computer for use in the calculations. No changes were made in the basic construct of the two codes and the modified codes produce output identical to the original codes.

2.2 THE FSCBG CODE

The FSCBG computer code (Dumbauld, et al., 1980) combines mathematical transport and dispersion models for calculating the dosage, peak concentration and deposition downwind from aerial spray releases. The FSCBG code contains algorithms designed to account for drop evaporation, canopy penetration and, as noted in Section 1, aircraft wake effects. The purpose of the aircraft wake effects algorithm is to describe the position of the spray cloud in space after wake effects have dissipated and atmospheric turbulence is the major mechanism controlling cloud dispersion. For present purposes, this point in space is referred to as the cloud stabilization point. At distances beyond the cloud stabilization point, the FSCBG code uses a Gaussian dispersion model for a finite line source which can treat dispersion from line sources formed at any angle with respect to the mean wind direction. The code uses the "tilted plume" concept to calculate deposition of drops at either the ground or canopy top. In the tilted plume concept, the axis of the spray cloud is assumed to be inclined from the horizontal plane by an angle that is proportional to $(V_j/\bar{u})$, where V_j is the graviational setting velocity of the jth drop-size category and $\bar{u}$ is the mean cloud transport speed. When evaporation is negligible, this angle is invariant with distance from the line source. For evaporating

drops, the angle changes with distance from the source because V_j depends on drop size. Evaporation effects on the drop size with distance from the source (V_j versus distance for a given drop-size category) can be calculated by an algorithm within the code structure or can be based on fits of quadratic equations to empirical data. The code structure contains an algorithm which uses Monte Carlo simulation techniques and the output of the deposition model at the canopy top to calculate the penetration of drops to various heights within a canopy and to the ground beneath the canopy.

2.3 SPRAY SCENARIO

A spray scenario was developed for use in examining the compatibilty of the AGLINE code output with the computer model requirements of the FSCBG code for the coordinates of the cloud stabilization point and the distribution of spray material at this point. In the scenario, a Thrush aircraft is assumed to spray Xylene (a carrier for the pesticide Endrin) at heights of 5 and 30 meters. The aircraft was assumed to release Xylene at a rate of 1 g m^{-1} along a line of 200 km in length to preclude any edge effects attributable to the finite line length. The spray releases at the two heights were assumed to be made during neutral stability conditions (Pasquill stability category D) with a wind speed of 4 m s^{-1} at a height of 10 m above the surface. The spray site was assumed to be flat terrain characterized by a roughness height (z_0) of 2 cm.

The inputs required by the AGDISP/AGLINE codes and the FSCBG codes for this scenario are described in Section 3.

SECTION 3
THE AGDISP, AGLINE AND FSCBG CALCULATIONS

3.1 THE AGDISP AND AGLINE CALCULATIONS

The model input requirements of the AGDISP and AGLINE codes are described in detail by Teske (1982a, 1982b). Table 3-1 lists the inputs used in the AGDISP calculations referenced to the Card Number specification in the AGDISP user's manual. The inputs describing the characteristics of the Thrush aircraft are based on values used by Teske and Ekblad during a meeting held at Salt Lake City, UT in December 1982, where the use of the AGDISP and AGLINE codes was demonstrated to personnel of the H. E. Cramer Company. The calculations were made for the 16 drop-size categories shown in Table 3-2. The fraction of mass in each drop-size category is based on empirical data for Xylene obtained from Mr. John Barry, MAG, USDA Forest Service in Davis, CA. No evaporation of the Xylene carrier was assumed to occur in these or the FSCBG calculations described in Section 3.2. As shown in Table 3-1, the calculations were limited to a maximum travel time of 20 s. The output AGPLOT file from the AGDISP code was used as direct input to the AGLINE code.

Because the FOM tended to increase until all drops were deposited on the ground, we arbitrarily selected 0.8 as the FOM value required at the point where the equivalent Gaussian distribution could be used to describe the source for the FSCBG model. Therefore, the mean height and the vertical and horizontal (alongwind) standard deviations of the equivalent Gaussian distributions were extracted from the AGLINE output when the FOM reached 0.8. The equivalent Gaussian distributions output by the AGLINE code are given in Table 3-3 for the two release heights of 5 and 30 m. As shown in Table 3-3, the FOM never reached a value of 0.8 for drops with diameters greater than about 149 μm for the release at 5 m. This result might be expected because, at this low aircraft altitude, the drops with these large diameters impact the ground before an equivalent Gaussian distribution can

TABLE 3-1

INPUTS FOR THE AGDISP CODE

Card No.	Parameter	Input	Units
10	Max Time	20	s
	Full Plane Solution	2	-
20	Rectangularly Loaded Wing	2	-
	Crosswind=Yes	1	-
	Semispan	6.03	m
	Height	5,30	m
	Aircraft Speed	46.3	$m\ s^{-1}$
	Single Wing Aircraft	0	-
22	Loading Circulation Value	37.84	$m^2\ s^{-1}$
28	Wind Speed at Reference Height	4.0	$m\ s^{-1}$
	Reference Height	10	m
	Surface Roughness Height	0.02	m
40	Aircraft Drag Coefficient	.07	m
	Planform Area of Aircraft	28.8	m^2
	Aircraft Prop Efficiency	0.75	-
	Shaftspeed	1800	rpm
	Propeller Radius	1.39	m
	Propeller Offset	-.5	m
50	Fixed Value of Turbulence Used	0	-
	Maximum Background Turbulence	0.337	$m^2\ s^{-2}$
	Maximum Value of the Background Turbulent Macroscale	30	m
60	Half-Plane Particles	5	-
	Centerline Particle=Yes	1	-
	Particle Offset	0	m
	Particle Diameter	*	-
	Particle Specific Gravity	0.868	-
	Evaporation=No	0	-

* Inputs provided in Table 3-2.

TABLE 3-2

DROP-SIZE DISTRIBUTION

Drop-Size Category	Mean Drop Diameter (μm)	Fraction of Total Mass in Category
1	44.8	0.001
2	82.8	0.009
3	121	0.02
4	149	0.03
5	175	0.04
6	214	0.10
7	257	0.10
8	293	0.10
9	353	0.20
10	415	0.10
11	463	0.10
12	525	0.10
13	592	0.04
14	661	0.03
15	728	0.02
16	792	0.01

TABLE 3-3

EQUIVALENT GAUSSIAN DISTRIBUTION PARAMETERS SELECTED
FROM THE AGLINE RESULTS

Release Height (m)	Drop Diameter (μm)	Time From Release (s)	Figure of Merit	Height (m)	Downwind Distance (m)	Horizontal Standard Deviation (m)	Vertical Standard Deviation (m)
5	792	1.7	0.27	0	3.5	5.5	2.9
	728	1.7	0.28	0	3.7	5.6	2.9
	661	1.9	0.29	0	4.1	5.8	3.0
	592	1.9	0.31	0	4.4	6.1	3.1
	525	1.8	0.35	0.2	4.9	6.4	3.3
	463	2.1	0.39	0.2	5.3	6.7	3.4
	415	2.4	0.43	0.3	5.9	7.0	3.5
	353	6.1	0.55	0	8.2	8.8	3.7
	293	5.0	0.59	1.0	9.2	8.8	4.4
	257	5.7	0.71	0.4	10.4	8.4	4.1
	214	4.3	0.75	0.8	10.5	8.3	4.4
	175	3.5	0.76	1.4	10.1	8.0	4.6
	149	8.9	0.80	1.6	19.0	11.7	5.2
	121	5.7	0.80	2.8	15.3	9.0	5.8
	82.8	4.4	0.80	2.8	13.7	8.4	5.7
	44.8	4.1	0.80	3.0	13.1	8.7	5.8
30	792	5.7	0.80	11.2	23.2	7.2	4.5
	728	5.8	0.80	12.0	23.8	7.4	4.7
	661	5.7	0.80	13.2	23.9	7.7	5.0
	592	5.7	0.80	14.4	24.2	8.0	5.2
	525	5.7	0.80	15.7	24.3	8.3	5.4
	463	6.0	0.80	16.3	26.1	8.8	5.8
	415	6.4	0.80	16.9	27.9	9.1	6.2
	353	8.4	0.80	16.4	37.0	9.9	7.8
	293	6.9	0.80	19.4	30.4	8.9	7.0
	257	5.4	0.80	21.5	24.2	8.6	6.4
	214	4.1	0.80	23.5	18.6	8.1	6.1
	175	3.2	0.80	24.9	14.4	7.7	5.8
	149	2.7	0.80	25.5	12.5	7.5	5.7
	121	5.9	0.80	24.6	27.0	8.9	7.9
	82.8	4.2	0.80	25.8	19.3	8.4	7.3
	44.8	2.9	0.80	26.5	13.7	8.0	6.7

be achieved. An FOM of 0.8 was achieved for all the drop-size categories when the aircraft altitude of 30 m was used in the calculations.

Because of funding limitations, we restricted the calculations of ground-level deposition using the FSCBG code to the release at the aircraft altitude of 30 m. It should be noted that the failure to achieve a high FOM value for the release at 5 m should not be interpreted as indicating a lack of compatibility between the AGLINE and FSCBG models. Both models would indicate that rapid near-field ground-level deposition of drops occurs for such a low release-height. The agreement between the ground-level deposition patterns predicted by the AGDISP and FSCBG models for low-level release should be examined when funds become available.

3.2 THE FSCBG CALCULATIONS

Deposition calculations for the scenario described in Section 2.3 were made using the FSCBG model under the following different assumptions about the position of the stabilized cloud:

- The position and cloud dimensions are defined by the AGLINE output

- The position and cloud dimensions are defined by the simple wake model currently incorporated within the FSCBG code

- The position of the cloud is defined by the aircraft altitude (no aircraft wake models employed)

The source and meteorological model inputs varied to some degree depending on the assumptions regarding the position of the stabilized cloud. The source inputs are given in Table 3-4 for the AGDISP/AGLINE and FSCBG wake models identified in the first column of Table 3-4 by the wake model designation. As indicated in the table, the AGDISP and AGLINE model calculations

TABLE 3-4

SOURCE INPUTS FOR THE FSCBG DEPOSITION CALCULATIONS

Wake Model	Parameter[1]	Mean Drop Diameter (μm)															
		792	728	661	592	525	463	415	353	293	257	214	175	149	121	82.8	44.8
AGDISP/ AGLINE	DX	23.2	23.8	23.9	24.2	24.3	26.1	27.9	37.0	30.4	24.2	18.6	14.4	12.5	27.0	19.3	13.7
	H	11.2	12.0	13.2	14.4	15.7	16.3	16.9	16.4	19.4	21.5	23.5	24.9	25.5	24.6	25.8	26.5
	σ_o	5.7	5.9	6.2	6.5	6.7	7.1	7.5	8.8	7.9	7.4	7.0	6.7	6.6	8.4	7.9	7.3
FSCBG	DX	35.1	38.5	42.9	47.5	53.0	59.6	66.0	81.1	102.1	117.1	133.9	133.9	133.9	133.9	133.9	133.9
	H	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
	σ_o	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1

[1] DX is the downwind distance to stabilization in meters, H is the stabilization height in meters and σ_o is the source dimension in meters.

provide estimates of the the stabilization distance DX, mean source height H, and standard deviations of the equivalent Gaussian distribution for each drop-size category. Because only a single source dimension σ_o can be used in the current FSCBG model, the following expression for the geometric mean of the horizontal standard deviation σ_H and vertical standard deviation σ_V was used to define σ_o for the FSCBG model calculations

$$\sigma_o = (\sigma_V \times \sigma_H)^{1/2} \tag{3-1}$$

As indicated in the Table 3-4, only the value of DX varies as a function of the drop-size category when the FSCBG model internally calculates the effects of aircraft wakes. The cloud stabilization height is always set equal to half the wingspan of the aircraft which is equal to 6.8 m for the Thrush. The source dimension σ_o was obtained by dividing the wingspan by 4.3, to yield 3.1 m. Finally, DX was set equal to 0, H equal to 30 m and σ_o equal to 3.1 m for the deposition calculations made without considering wake effects.

The meteorological inputs used in the FSCBG deposition calculations are shown in Table 3-5. As noted in Section 2.3, the calculations were made for neutral atmospheric stability conditions and a mean wind speed of 4 m s^{-1} at a height of 10 m. The mean wind speed u and the turbulence parameters σ_A and σ_E shown in Table 3-5 are mean values between a height of 2 m and the height H shown in Table 3-4 for the calculations made using the AGDISP/AGLINE input parameters. For the FSCBG wake model and the calculations made without the wake models, the values of u, σ_A and σ_E are mean values for the layer between 2 m and the aircraft altitude H. The height profiles used to obtain the mean values are based on the power-law expressions defined by Dumbauld (1982) for a net radiation index of 0 and mean wind speed of 4 m s^{-1}. The values of σ_A in the table are for a source function time τ of 2.5 s and the roughness height of

TABLE 3-5

METEOROLOGICAL INPUTS FOR THE FSCBG DEPOSITION CALCULATIONS

Wake Model	Drop Diameter (μm)	Mean Wind Speed u ($m\ s^{-1}$)	$\sigma_A(\tau=2.5s)$ (deg)	σ_E (deg)
AGDISP/ AGLINE	792	3.4	4.1	4.1
	728	3.5	4.1	4.1
	661	3.5	4.1	4.1
	592	3.6	4.2	4.2
	525	3.6	4.2	4.2
	463	3.7	4.2	4.2
	415	3.7	4.2	4.2
	353	3.7	4.2	4.2
	293	3.8	4.3	4.3
	257	3.8	4.3	4.3
	214	3.9	4.3	4.3
	175	4.0	4.4	4.4
	149	4.0	4.4	4.4
	121	3.9	4.4	4.4
	82.8	4.0	4.4	4.4
	44.8	4.0	4.4	4.4
FSCBG[1]	all	4.2	4.4	4.4
None[1]	all	4.2	4.4	4.4

[1] Parameters are not dependent on the drop-size distribution.

2 cm. The variation in σ_A and σ_E for the calculations made using the AGDISP/AGLINE inputs is small and did not have an appreciable affect on the deposition calculations.

The results of the deposition model calculations made under the three assumptions regarding wake effects are shown in Figure 3-1. There is little difference in the results obtained under all three assumptions in the first 300 m downwind from the source, except that the calculations made using the AGDISP/AGLINE inputs (solid line) show the peak deposition occurring slightly closer to the release line. This is likely due to the slightly lower wind speeds used with the AGDISP/AGLINE inputs. At longer downwind distances, the deposition estimates calculated under the assumption that wake effects do not affect the deposition (dotted line) are greater than those calculated using the wake models. This result is explained by the higher release height assumed in the calculations made without wake effects which allows drops to be transported to a longer distance before impacting the ground.

It should be noted that the effect of the wake models on the deposition patterns is expected to decrease as the release height or aircraft altitude is increased. Thus, aircraft altitudes below the 30 m height used in these calculations may show greater differences in deposition levels than indicated in Figure 3-1.

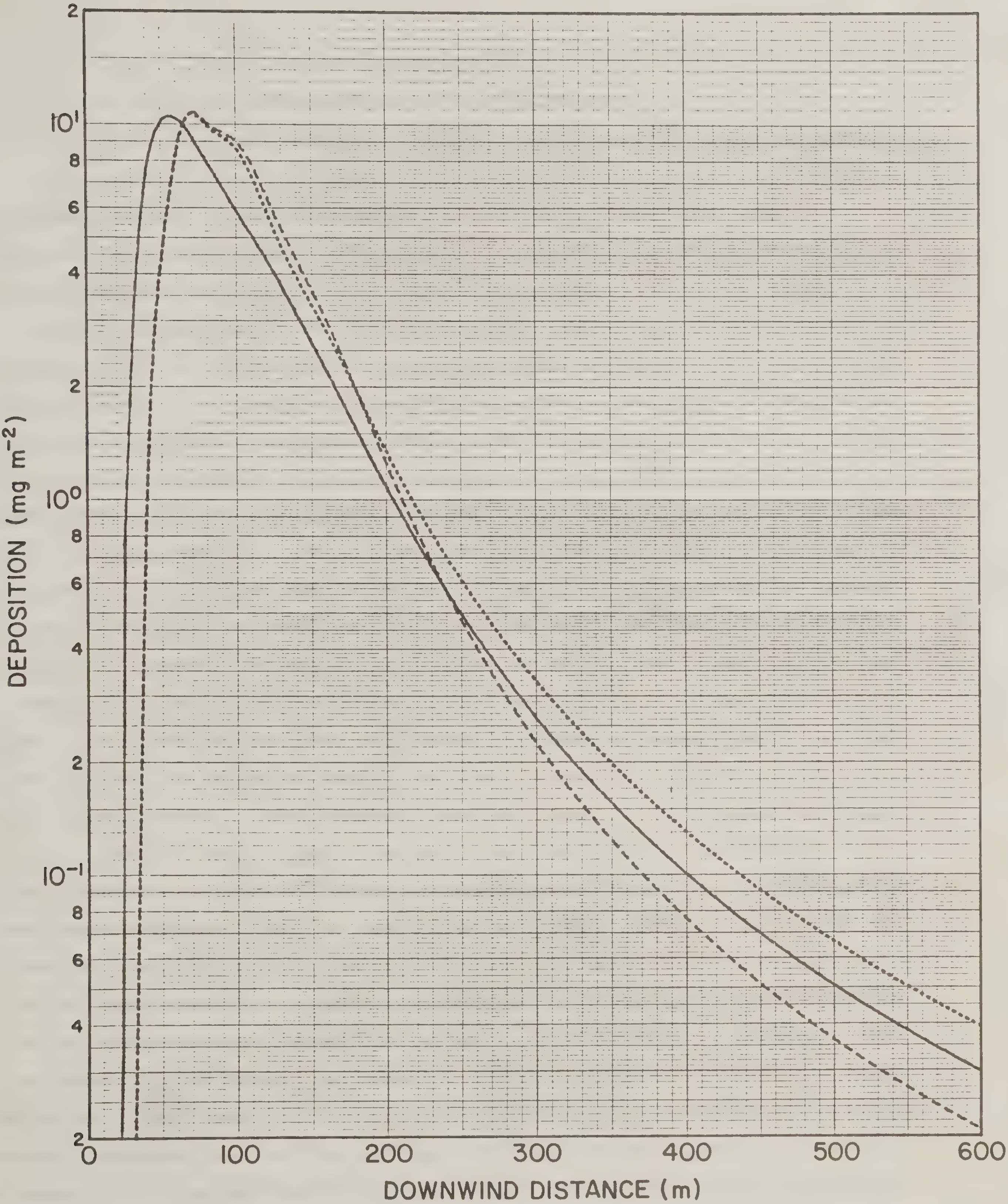

FIGURE 3-1. Results of the deposition calculations made using the FSCBG code. The solid line and dashed line respectively represent results obtained using inputs from the AGDISP/AGLINE codes and the FSCBG wake modcl. Results obtained made without considering wake effects are shown by the dotted line.

SECTION 4
CONCLUSIONS AND RECOMMENDATIONS

The AGLINE/AGDISP codes show promise of being a useful addition to the FSCBG modeling capability. However, the limited number of calculations performed indicate that some modifications should be made in both the AGLINE and FSCBG codes before the full utility of a code merger can be established. For example, the sensitivity of the FSCBG deposition model to the choice of equivalent Gaussian distributions output by the AGLINE code as a function of the figure of merit (FOM) designation should be examined in further detail. Such a study may, for example, eliminate the requirements for carrying out the AGDISP/AGLINE calculations for drops with small diameters to excessively long travel times. Also, an investigation should be made of the sensitivity of the FSCBG deposition calculations obtained from the AGDISP/AGLINE output to the flight altitude in conjunction with the examination of procedures for selecting equivalent Gaussian distributions. Alternative or additional criteria for selecting the equivalent Gaussian distribution produced by the AGLINE code may be developed. Examination of the AGLINE code output for the limited calculations made in this study indicates that, at least for near ground-level releases, large values of the FOM cannot be achieved from drops with large diameters where the gravitational settling velocity greatly exceeds the vertical velocities in the wake. On the other hand, the achievement of large values of the FOM is not likely necessary since the trajectories of very large drops are nearly ballistic and the ground-level deposition patterns of these drops is not very sensitive to wake effects. Thus an additional criteria such as the ratio of the mean vertical velocity of drops in a given size category to the gravitational settling velocity for this size category may provide an additional criteria for use in selecting the appropriate equivalent Gaussian distribution for input to the FSCBG model. An examination of the degree of agreement between ground-level deposition patterns predicted independently by the FSCBG and AGDISP codes for low-altitude releases may reveal other possible selection criteria.

Finally, a library of appropriate inputs for the various types of fixed-wing and rotor spray aircraft should be developed and complete automation of the selection of input parameters from the AGDISP/AGLINE codes to the FSCBG code should be accomplished before the full benefits of the merged code can be realized in applications to USFS spray programs.

[illegible] water spray ... [illegible]
selection of input parameters [illegible]
code should be accomplished [illegible]
[illegible]

[illegible]

[illegible] analysis [illegible]
[illegible] selection [illegible] results
[illegible] the KALEST [illegible] may be developed. [illegible]
[illegible] relations [illegible]
[illegible] ground-level [illegible], large [illegible]
[illegible] with large [illegible]
[illegible] exceeds the critical value [illegible]
[illegible] achievement of large values of the [illegible]
[illegible] [illegible], very large drops are [illegible]
[illegible] deposition patterns of these drops [illegible]
[illegible] and criteria such as
[illegible] velocities of drops [illegible] given
[illegible] for this size [illegible]
[illegible] selecting the [illegible] equivalent
[illegible] of the FACTOR model. An examination of [illegible]
[illegible] ground-level deposition pattern [illegible]
[illegible] for [illegible] model [illegible]
[illegible] criteria.

REFERENCES

Dumbauld, R. K., J. R. Bjorklund and S. F. Saterlie, 1980: Computer models for predicting aircraft spray dispersion above and within forest canopies: User's manual for the FSCBG computer program. Report No. 80-11, U. S. D. A. Forest Service, Methods Applications Group, Davis, CA.

Dumbauld, R. K., 1982: Aerial spray application and long-term drift. Proceedings of the Workshop on the Parameterization of Mixed Layer Diffusion. Edited by R. M. Cionco, U. S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, N.M.

Teske, Milton E., 1982a: Numerical studies of the deposition of agricultural materials from fixed and rotary wing aircraft: AGDISP (MOD 1.0) user manual. Continuum Dynamic, Inc. Tech. Note 81-14 prepared for NASA Langley Research Center, Hampton, VA.

Teske, Milton E., 1982b: Numerical studies of the deposition of agricultural materials from fixed and rotary wind aircraft: FSCBG conversion AGLINE (MOD 0.0) user manual. Continuum Dynamics, Inc., Tech. Note 82-23 prepared for NASA Langley Research Center, Hampton, VA.

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